NEWSLETTER V - JANUARY 2023

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INNOVATIVE FUTURE-PROOF TESTING METHODS FOR RELIABLE CRITICAL COMPONENTS IN WIND TURBINES

3 COUNTRIES

4.8 M€ BUDGET

8 PARTNERS

36 MONTHS

INNTERESTING ID

Acronym
Horizon 2020- INNTERESTING

Program
The European Union´s Research and Innovation Program Horizon 2020 LC-SC3-RES-1-2019-2020
Developing the next generation of renewable energy technologies

Duration
January 2020- December 2022

Main objective
To accelerate wind energy technology development and to extend the lifetime of wind turbine components by developing innovative virtual and hybrid testing methods for prototype validation of pitch bearing and gearbox components.

Partner countries
Belgium, Finland, Spain

EDITORIAL

Dear readers

After three years of research and development, INNTERESTING has reached its end, having successfully achieved every established milestone. Project partners would like to thank all the stakeholders that have supported the activity for the effort made so far. This edition of the Newsletter covers the main outcomes, lessons learned and results of the project, as well as the last activities and conferences organized by the partners.

More specifically, two important milestones are detailed in this newsletter, on the one hand the final conference of the project organized within the framework of Wind Energy Hamburg Conference, which is the largest wind energy event in Europe; and on the other hand, the final meeting and subgroup meetings held with expert representatives from the Technical Advisory Group that has supported the project in its technical aspects.

Lastly, we will keep you up to date about the project partners´ activities and initiatives related to INNTERESTING by providing short summaries of the latest project events.

We hope you will enjoy reading this last issue of the INNTERESTING Newsletter. Latest and updated news can also be followed through our website:

www.innterestingproject.eu/project/

Please do not hesitate to interact with us, your feedback and comments are always welcome!

Yours sincerely,

The INNTERESTING consortium

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 851245.

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PROJECT PROGRESS

INNTERESTING HAS REACHED ITS END

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Figure 1 – Project partners during the final Steering Committee in Bilbao (December 2022)

During the final meeting, a complete agenda was followed with two days of Consortium Meeting where partners valued what they have learned and obtained as knowledge/tool/methodology and after the work developed in the project. Each partner presented the following aspects of the work carried out:

- Summary of the outcomes
- Methodologies, tools, models developed.
- Acquired knowledge
- Good practices
- Things to improve

Additionally, partners attended site visits to WINDBOX testing facilities and to IKERLAN, as well as social events like a visit to the Guggenheim Museum and a “Pintxos” route.

On the last day of the meeting, the INNTERESTING consortium met with the Technical Advisory Group (TAG) of the project to discuss the final outcomes and possible next steps, and the Subgroups 4 and 5 also had the opportunity to discuss on virtual sensing and test benches.

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Need of larger/more expensive test benches

The INNTERESTING project has worked to develop a novel hybrid methodology and breakthrough design tools to assess reliability of larger wind turbine critical components without the need of building larger test benches in the future. It is not possible to avoid large test benches, but do they need to be 1:1?

The INNTERESTING APPROACH can be an additional supplement to acquire knowledge more efficiently

Figure 2 – Failures in field

Failure modes due to:

- Manufacturing process effect on the structural reliability
- Material´s variability
- Scale effect on the structural reliability

INNTERESTING CAN CONTRIBUTE TO:

- Improve manufacturing processes
- Improve and optimize component´ s designs
- Test definition/test campaign
- Probability of failure of the components instead of deterministic damage value.

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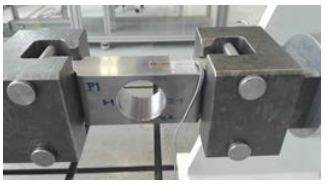
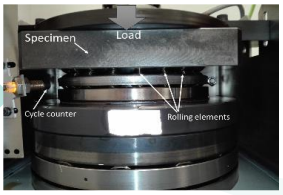
Problems that can be overcome by using the methodology developed in the project

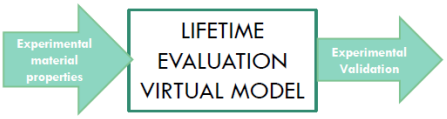
Damage calculation methodologies and virtual models for specific failure modes:

- DIFFICULTY OF MATERIAL CHARACTERIZATION INPUTS AND VALIDATION
  - Polished surfaces → modifications of the curves to the real roughness values
  - Ring structural failure



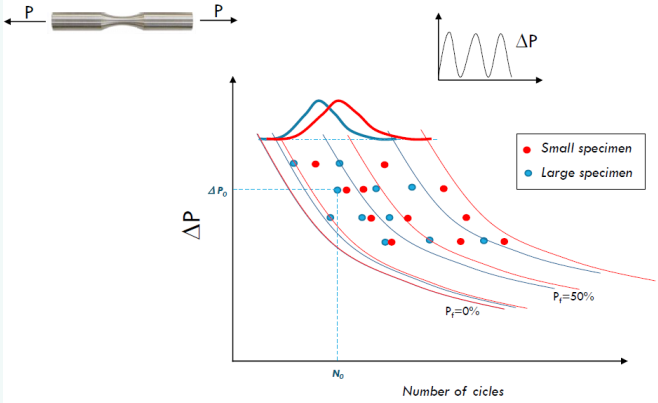
  - Rolling contact fatigue





Simplified tailored tests reduce the uncertainties coming from the material ´ s characterization

- FATIGUE CURVES



At the same stress/load/ pressure level , the probability of failure for the large specimen is higher than the probability for a small specimen.

It is not conservative not to consider this effect and to design components based on the small specimen curves. This is the reason why the scatter in smaller specimens is so high.

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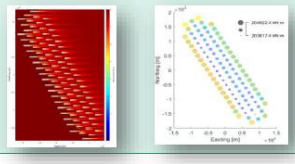
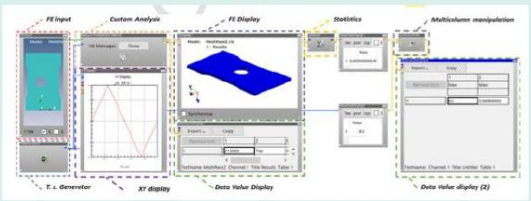
RESULTS

ADVANCE VIRTUAL TESTS AND DESIGN TOOLS

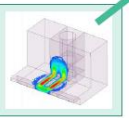
PROBABILISTIC LOAD CALCULATION METHODS
Developed a numerical approach to quantify stochastically the pitch bearing fatigue del variability between WTGs of a wind farm



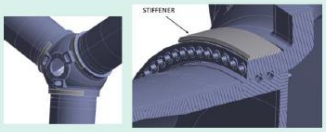
RELIABILITY PREDICTION METHODS FOR WT COMPONENTS
Developed a stochastic numerical approach for estimating global WT structure fatigue probability of failure

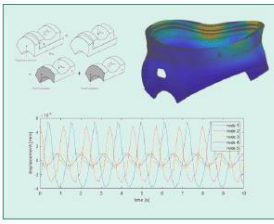


MANUFACTURING AND MATERIAL EFFECTS ON WIND TURBINE COMPONENT LIFETIME
A fast Multiphysics simulation methodology for induction hardening process is developed



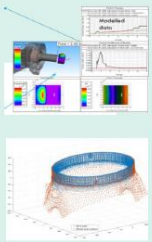
RELIABILITY METHODS FOR LIFETIME EXTENSION OF EXISTING PITCH BEARINGS: A design procedure to define life extension solution (based on a patented idea)



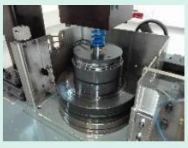


DEVELOPMENT OF SCALABLE PITCH MULTI BODY BEARING MODELS
Focused on the development of analytical models and flexible multibody models for 4 and 8 point of contact ball bearings

SENSOR SELECTION TECHNIQUE
Developed a sensor selection technique to automatically suggest sensor sets for the estimation of the loads on a pitch bearing and monitor the sensors to monitor the lubricant film thickness in the journal bearing of the gearbox



SIMPLIFIED TAILORED PHYSICAL TESTING



EXPERIMENTAL CHARACTERIZATION OF THE MANUFACTURING EFFECT ON THE FATIGUE PROPERTIES
Induction hardening process effect on the fatigue properties

CONTACT FATIGUE FAILURE MODES: ROLLING CONTACT FATIGUE
Analysis of the RCF failure mode with flat smaller samples

CHARACTERIZATION OF REPAIRS SOLUTIONS adhesive material characterization that will be used for the CS3 (patented idea)

STRUCTURAL FATIGUE FAILURE TESTING FOR WIND TURBINE COMPONENTS
Simplified bolt hole tests using the bearing material. This is linked to the reliability prediction virtual methods

NEW PITCH BEARING CONCEPT VALIDATION TEST
CS1 novel roller concept is validated in a 400 Tn test bench

LABORATORY-SCALE TESTS FOR JOURNAL BEARING CONCEPT
Analysis of the failure cases of the journal bearing concept using new type of materials

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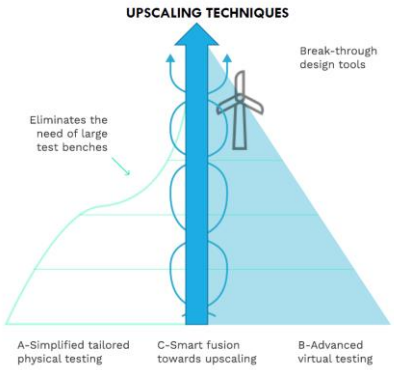
UPSCALING TECHNIQUES



The hybrid pyramid proposed in this project is based on 3 different pillars: the tailored simplified tests, the advanced virtual models, and the upscaling techniques. Using upscaling techniques the prediction of the real scale component's reliability is obtained.

The final reliability value, instead of the usual deterministic damage value, will be defined as a **probability of failure**. The concept of using a probabilistic reliability evaluation instead of the usual deterministic **damage** evaluation, changes completely how the industry evaluates the lifetime of the components. Using the probability of failure, it is possible to analyse:

- It considers the possibility of having a failure in other places different from the maximum damage point.
- The evaluator knows the risk that is assuming with this probability of failure of the global component (under this specific failure mode).

The results obtained in this project clearly show that it is necessary to consider the difference in the size of the component from the tests performed to the real size design. If this size effect is not included in the evaluation, the results will be non-conservative.

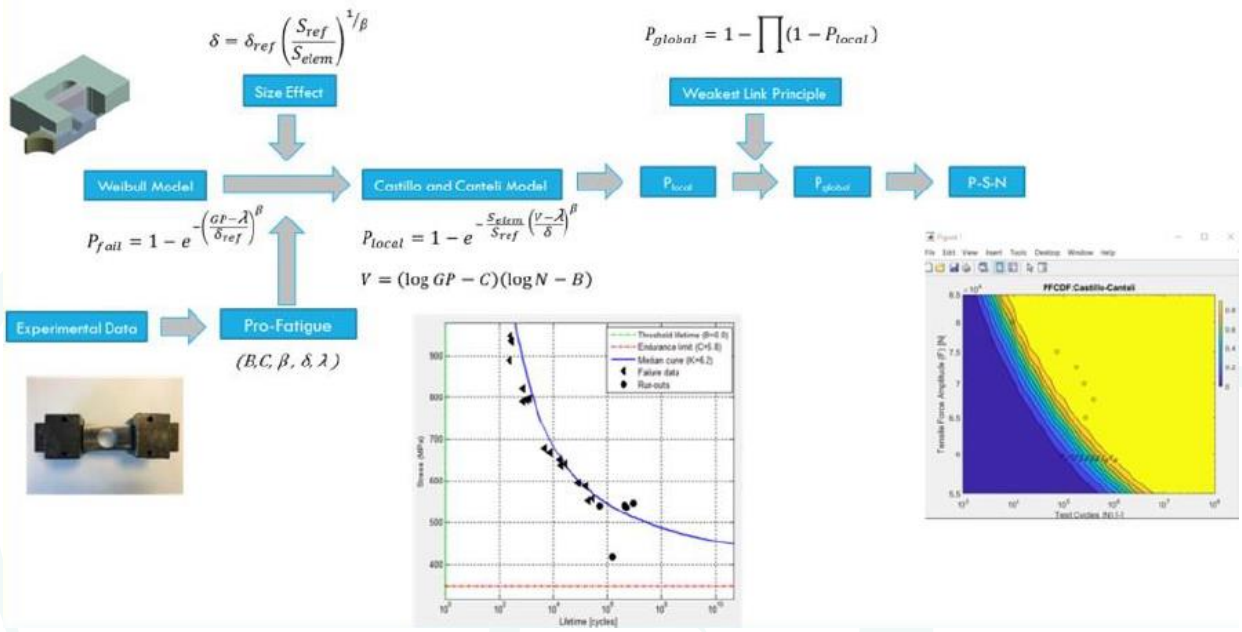


Figure 3 - Upscaling methodology

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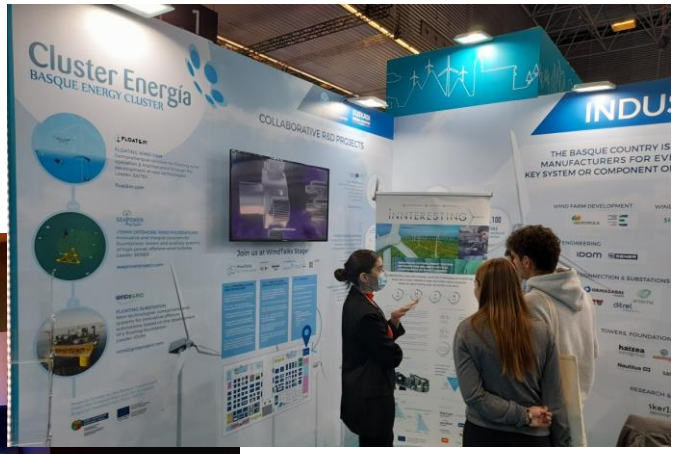
RELEVANT PRESENCE AT WINDEUROPE ANNUAL EVENT BILBAO 2022

Apr. 2022| INTTERESTING PROJECT HAS A RELEVANT PRESENCE AT WINDEUROPE ANNUAL EVENT BILBAO 2022.

The WindEurope Annual Event was back in Bilbao for 2022. In the framework of the event, the INNTERESTING project had an extensive presence at the Basque Energy Cluster stand and participated in the Conferences of the event.

Mireia Olave from Ikerlan, project coordinator of INNTERESTING project presented the project in the session Development on new hybrid testing methodologies for reliable critical components in wind turbines. She centred her speech on lifetime extension and reliability evaluation of a new concept for pitch bearings, concretely in a novel stiffening concept for lifetime extension of existing pitch bearings.

Additionally, the Basque Energy Cluster Stand included in its graphic wall the project among the most noted innovative European projects.



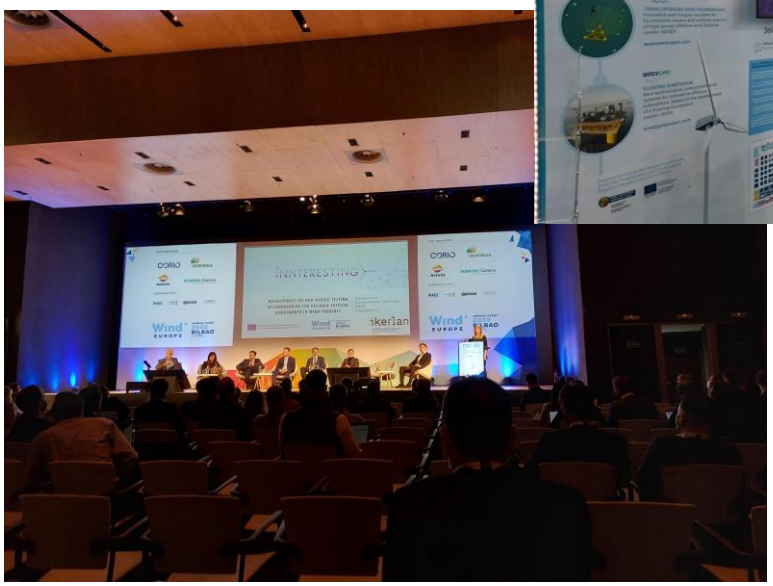


Figure 4 – Presentation of INNTERESTING during the official conference in Wind Europe Bilbao, and presence in the stand of the Basque Energy Cluster

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Sept. 2022| INNTERESTING ORGANIZES THE FINAL EVENT OF THE PROJECT WITHIN THE FRAMEWORK OF THE WIND ENERGY HAMBURG FAIR

The conference, organized by IKERLAN and the Energy Cluster Association (ACE) in collaboration with the partners of the INNTERESTING project, was held on September 28 at the Wind Energy Hamburg 2022 fair. During the conference, representatives of these companies presented their contributions to the result of the project and shared the latest knowledge and trends in the sector.

The workshop had a first block in which Mireia Olave (IKERLAN), as coordinator, gave an overview of the objectives and technical scope of the project based on an analysis of the future of wind energy in terms of tests and component sizes.
Aitor Zurutuza (LAULAGUN) showed the results obtained from the pitch bearing design concept for a 20 MW offshore wind turbine. The concept is based on a 3-row roller bearing (3RRB) and must meet the load, structural and environmental requirements defined for future larger wind turbines: high extreme and fatigue loads, bearing structural integrity and environmental conditions. extreme.
Helena Ronkainen (VTT) recounted the progress made together with MOVENTAS for a novel gearbox design concept for a 10 MW onshore wind turbine with a hub height of 119, a rotor diameter of 202 m and a torque density up to the level of 200Nm/kg.
Mireia Olave (IKERLAN) showed a novel reinforcement concept to extend the useful life of existing pitch bearings for a 3.4 MW wind turbine. In this case study, the pitch bearing is expected to fail early in its life (<10 years), for which a bearing repair and reinforcement solution will be required.
Finally, Wai Chung Lam (VITO) presented the results of the environmental, social and economic evaluation of the three case studies presented above.

The event closed with some conclusions by the coordinator Mireia Olave, in which she highlighted the strong impact potential of INNTERESTING due to the future trend of wind energy in terms of sizes of wind turbines and components.

Figure 5 - Final meeting of INNTERESTING during Wind Energy Hamburg 2022

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LAST MEETINGS WITH THE TECHNICAL ADVISORY GROUP (TAG)

Nov. 2022| Subgroup meeting: Hybrid testing methodology for pitch bearings

The subgroup meeting was held on the 24th of November online. The objective of the meeting was to show the development of the project focused on pitch bearings and to obtain feedback, advice, and comments from the experts. The meeting was divided into three sessions:

- Reliability prediction and validation of pitch bearings
- Simulation of induction hardening of pitch bearing and effect on lifetime
- Design and validation of pitch bearing repairs for lifetime extension

Dec. 2022| 3rd INNTERESTING Technical Advisory Group meeting

The 3rd INNTERESTING Technical Advisory Group meeting was held on the 2nd of December 2022 together with the meeting of SG4 and SG5 in Bizkaia Aretoa UPV/EHU and online.

A summary and conclusions of the project was presented to the experts, following the next outline:

- Introduction
- What we have learned
- Brief review of the results
- Conclusions

As a conclusion, it was highlighted that a big amount of money is currently spent by companies and governments for testing facilities, and that having acquired knowledge in this aspect thanks to the project will help to save both time and money in the future.

Subgroup meeting: Virtual sensing and test benches

The objective of the subgroups meeting was to show the development of the project focused on virtual sensing and test benches to obtain feedback, advice, and comments from the experts. The meeting was divided into three sessions:

- Virtual sensing as a tool for design, monitoring and upscaling
- Virtual sensing
- Test-benches

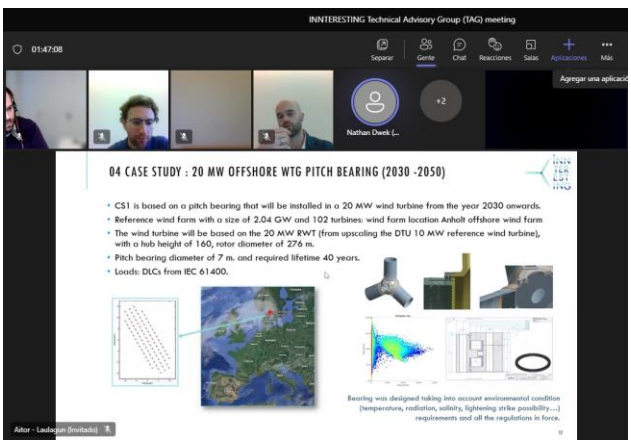

Figure 6 – Project partners during the TAG meeting in Bilbao (December 2022)

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REVIEW OF THE OBJECTIVES

develop design tools

bring two new ground-breaking designs of real wind turbine components to a TRL-4

Case Study 1

Case Study 2

Case Study 3

reduce the environmental and economic impacts

Replication of project results to other components and sectors

The INNTERESTING Project aims to develop a novel hybrid methodology and breakthrough design tools to assess reliability of larger wind turbine critical components without the need of building larger tests benches in the future

FINAL TECHNICAL CONCLUSIONS

- ✓ The methodology has been validated on each case study for which the INNTERESTING approach was developed.
- ✓ The INNTERESTING approach not only tests or validates the component, but it also provides knowledge about the effect of variability in the manufacturing processes of materials and about specific failure modes that otherwise would be very expensive to obtain.
- ✓ The downscaled tests have been trending thanks to their lower cost, but upscaling techniques are necessary.
- ✓ A new concept should be considered in the industry: probability of failure of the components, instead of deterministic damage value.
- ✓ Recently popularized technologies such as A.I. and Machine Learning can be used for reliability prediction, but it is important to understand what is physically happening

Conclusion: **MORE RESEARCH IN UPSCALING TECHNIQUES MUST BE DONE**

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INNTERESTING

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MEMBER OF BASQUE RESEARCH & TECHNOLOGY ALLIANCE

moventas
GEARED FOR NEW ENERGY

LAULAGUN bearings

KU LEUVEN

vito

SIEMENS
Ingenuity for life

Energy Ville

VTT

Cluster Energía
BASQUE ENERGY CLUSTER

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